(19) Europäisches Patentamt
Europ an Patent Office
Office européen des brevets

(11) Publication number: **0 040 035**
A1

(12) # EUROPEAN PATENT APPLICATION

(21) Application number: 81301966.8

(22) Date of filing: 05.05.81

(51) Int. Cl.³: H 01 B 7/02
H 01 B 3/04

(30) Priority: 08.05.80 GB 8015250

(43) Date of publication of application:
18.11.81 Bulletin 81/46

(84) Designated Contracting States:
AT BE CH DE FR GB IT LI LU NL SE

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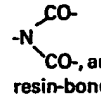
(54) Electric cables.

(57) An insulated conductor suitable for continuous service at high temperatures (e.g. 150-180°C) and which under fire conditions resists short-circuiting and does not evolve large amounts of visible smoke or toxic fumes has principal extruded insulation based on a polymer consisting of chains of aromatic rings linked by groups selected from -O-, -S-, $-SO_2-$ (where R=H or alkyl or acyl) -NHCO-,  -N<CO- and -CO.O-. Secondary, fire-surviving, insulation is of resin-bonded mineral-fibre reinforced mica paper tape. This may be under or over the principal insulation.

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ELECTRIC CABLES

This invention relates to electric cables having at least two conductors insulated from one another, and to insulated conductors for use therein.

The object of the invention is to provide a cable suitable for continuous service at high temperatures (say up to around 150-180°C), which resists short-circuiting for a useful length of time (say at least 30 minutes) under fire conditions, which does not evolve any large quantity of visible smoke or toxic gas if burned, and which maintains (under normal service conditions) good mechanical and electrical properties.

Glass-fibre reinforced mica paper tape has been used to impart limited fire-survival characteristics to certain polymer-insulated cables, but is ineffective with most conventional high-temperature polymeric insulating materials.

In accordance with the present invention, an electric cable, or an insulated conductor for use therein, comprises at least one metallic conductor and surrounding insulation comprising (i) extruded principal insulation based on a polymer consisting of chains of aromatic rings linked by groups selected from -O-, -S-, $-SO_2-$, -CO-, $-CR_2-$ (where R=H or alkyl or acyl) -NHCO-, $-N<^{CO-}_{CO-}$, and -CO.O-, and (ii) secondary insulation comprising at least one tape of a resin-bonded mineral-fibre reinforced mica paper.

The principal insulation is pref rably extruded either as a single operation or in two (or more) steps.

Alternatively it might be in tape form applied helically or applied longitudinally, or as a further alternative it could be applied initially in a longitudinal direction and subsequently converted to a helical form by twisting the wrapped wire (before or after applying any further layer), for example by using a flyer-type winding machine (as conventionally used for twinning and bunching). Further it might be a composite layer applied partly in tape form and partly by extrusion (under, over or between tapes). When the outer layer is in two or more parts they may be of identical composition or they may differ within the range of polymers defined above.

The secondary insulation may be inside the principalinsulation (which is in most cases most effective in providing fire survival characteristics) or outside it (which tends to be better from the point of view of low combustibility and smoke hazard), or may be present in both these positions. Alternatively (or in addition) it could be interposed between layers of principal insulation. The principal and secondary insulation may, but need not, be bonded together at the interface.

The conductor may be solid or stranded and may be of plain, tinned, nickel-plated, nickel-clad or silver-plated copper.

Suitable polymers for the principal insulation ar described in British Patent Specifications 971,227, 1,016,245, 1,019,266, 1,019,458, 1,078,234, 1,086,021,

1,102,679, 1,153,035, 1,153,527 1,164,817, 1,177,183, 1,383,393, 1,387,303, and 1,414,421, 1,414,422, and 1,414,423 and in European Patent Application 0001879. Linear polymers are usually preferred, but some can be crosslinked and this may sometimes be beneficial. Polymers in which the aromatic groups are predominantly phenylene and the linking groups are selected from -O-, -CO- and $-SO_2-$ are preferred; most preferred are polyether-ketones and polyether sulphones in which (in both cases) -O- linkages are in the majority, and more especially para phenylene polyetherketones having about twice as many -O- linkages as -CO- linkages, such as that sold by ICI as "PEEK".

Preferably the principal insulation layer is oriented, suitable techniques for extruded layers being described in our British Patent Application 16614/78 and our European Application No. 79301544.7.

The precise structure of the mica paper constituent of the tape comprising the secondary insulation is not critical, but the particles should be sufficiently densely packed to make the mica paper self-supporting; on the other hand large flakes or splittings of mica do not form an adequate substitute for mica paper. Mica paper prepared from phlogopite is preferred, but muscovite mica paper can be used.

The reinforcing mineral fibres are preferably glass fibres, but other mineral fibres of high tensile strength (such as asbestos fibres) could be used. They may run in the longitudinal direction of the tape only,

or th y may run in mor than one dir ction with or without being woven together.

Any type of bonding resin that adheres satisfactorily to the mica paper and the fibres and has adequate flexibility and maintains electrical insulation under fire conditions can be used. The preferred bonding resin is based on a silicone. Since the resin is itself a combustible material, the minimum amount of resin compatible with satisfactory bonding should be used. When the resin is heat-curable, it may usefully be in an incompletely cured state when the tape is applied. The reinforced mica paper tape is preferably applied helically to the cable core, but longitudinal taping could be used provided either that the edges of the tape are overlapped and securely fixed down or that the cable core is subsequently twisted as described above.

Example I

A core comprises 19 annealed copper wires each 0.15mm in diameter conventionally stranded together and lapped with a 6mm wide mica paper tape applied with a nominal overlap of 50%. The tape is sold by General Electric Co. under the reference number 77935 and comprises mica paper with longitudinally-extending glass fibres bonded to it with a silicone resin; its nominal overall thickness is 0.1mm. Over the tape is extruded a layer of a polyphenylene ether-ketone with about two ether linkages per ketone linkage (suitably pigmented if desired but without other additives), using a conventional thermoplastic extruder operating at about

400°C. The radial thickness of this layer is 0.4mm.

The core is completed by an extruded layer, 0.8mm radial, of an ethylene-acrylate composition formulated as follows:

	Parts by weight
Vamac N-123 masterbatch (believed to consist of about 80% of a terpolymer of ethylene, methyl acrylate and a carboxylic monomer together with about 20% of an inert silica filler)	47.50
Hydrated alumina, Paper grade SD (particle size around 1 micrometre)	44.63
Silica filler (Vulcasil S)	1.91
Process Aids:	
Stearic acid	0.80
Another fatty acid sold as 'Armeen 18D'	0.20
Antioxidant:	
Santowhite powder	0.76
Solid formulation of vinyl trimethoxy silane (Drimix silane A172)	0.60
Curing system:	
Peroxide (40% active) (Perkadox 14/40)	2.70
Triallyl cyanurate (75% active on powder carrier) (Drimix 75% TAC)	0.90
	100.00

Example 2

This is a core similar to Example 1 except that the mica tape is that sold under the d signation 'Isola reference 366-21' comprising mica paper and a woven glass fabric bonded together with a semicured silicone resin; the dimensions are the same as in Example 1.

Examples 3-4

These are cores identical with those of Examples 1 and 2 respectively except for the omission of the outer copolymer layer.

Examples 5-6

The cores of Examples 3 and 4 respectively are braided with 0.8mm diameter tinned annealed copper wires applied 16 spindles/5 ends/7mm lay and sheathed with the ethylene/acrylate copolymer compound set out in Example 1 above to form a cable 4.4mm diameter (sheath 0.8mm radial).

Examples 7-8

Nineteen of the cores of Example 3 and Example 4 respectively are laid up in a conventional manner (1,6,12) with a lay length for each of the layers equal to 25 times the respective pitch diameter. The core assembly (with a diameter of about 10mm) is lapped with a 25mm x 0.025mm Melinex (polyethylene terephthalate) tape applied with 20% overlap and sheathed to a radial thickness of 1.27mm with the ethylene/acrylate composition set out in Example 1; finished diameter about 12.54mm.

Examples 9-10

Th se are similar to Examples 7 and 8 respectively, except that

(i) between the core assembly and the Melinex tape is interposed a braid of 0.15mm diameter tinned annealed copper wires applied 24 spindles/8 ends/26mm lay;

(ii) between the Melinex tape and the sheath is a heat-sealable coated polyester tape (sold under the trademark Lamiglas) with the same dimensions and lay as the Melinex tape; and

(iii) the radial thickness of the sheath is 1.1mm (giving an overall diameter of about 14.0mm).

Examples 11-12

Twisted pairs of the cores of Examples 3 and 4 respectively are lapped with a Melinex tape 15mm x 0.025mm, 20% overlap. A screen of tinned annealed copper wires each 0.10mm in diameter applied 16 spindles/4 ends/15mm lay is followed by another Melinex tape and then a Lamiglas tape with the same dimensions and overlap as the first Melinex tape.

Seven of the resultant pairs are laid up at 25 times the pitch diameter and lapped with a further Melinex tape, this time 30mm x 0.025mm, applied with 20% overlap. An extruded ethylene/acrylate sheath, 1.2mm radial thickness, of the formulation set out in Example 1, completes a cable about 18.0mm in diameter.

CLAIMS

1. An electric cable, or an insulated conductor for use therein, comprising at least one metallic conductor and surrounding insulation comprising (1) principal insulation comprising a polymer consisting of chains of aromatic rings linked by groups selected from -O-, -S-, $-SO_2-$, -CO-, $-CR_2-$ (where R=H or alkyl or acyl) -NHCO-, $-N<^{CO-}_{CO-}$, and -CO.O-, and (2) secondary insulation comprising at least one tape of a resin-bonded mineral fibre reinforced mica paper.

2. An insulated wire or cable as claimed in Claim 1 in which the linking groups are selected from -O-, -CO- and $-SO_2-$.

3. An insulated wire or cable as claimed in Claim 1 in which the polymer is a polyether ketone in which the linking groups are -O- and -CO-, -O- groups being in the majority.

4. An insulated wire or cable as claimed in any one of Claims 1-3 in which the aromatic groups in the polymer are predominately phenylene groups.

European Patent Office

0040035
Application number
EP 81 30 1966

EUROPEAN SEARCH REPORT

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
	NL - A - 72 03717 (AKZO N.V.) * Claims 1-5; example 3; page 7, page 5, lines 14-25 *	1,2,4
A	GB - A - 923 940 (ASSOCIATED ELECTRICAL INDUSTRIES LTD) * Claim 2 *	1
A	US - A - 3 425 865 (F. SHELTON) * Claim 1 *	1

CLASSIFICATION OF THE APPLICATION (Int. Cl.³)

H 01 B 7/02
3/04

TECHNICAL FIELDS SEARCHED (Int. Cl.³)

H 01 B 3/04
3/42
7/34
7/02

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	17-08-1981	VAN DEN BULCKE